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TITLE

Mineralogical Characterization of Airborne Industrial Pollutants

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Mineralogical Characterization of Airborne Industrial Pollutants

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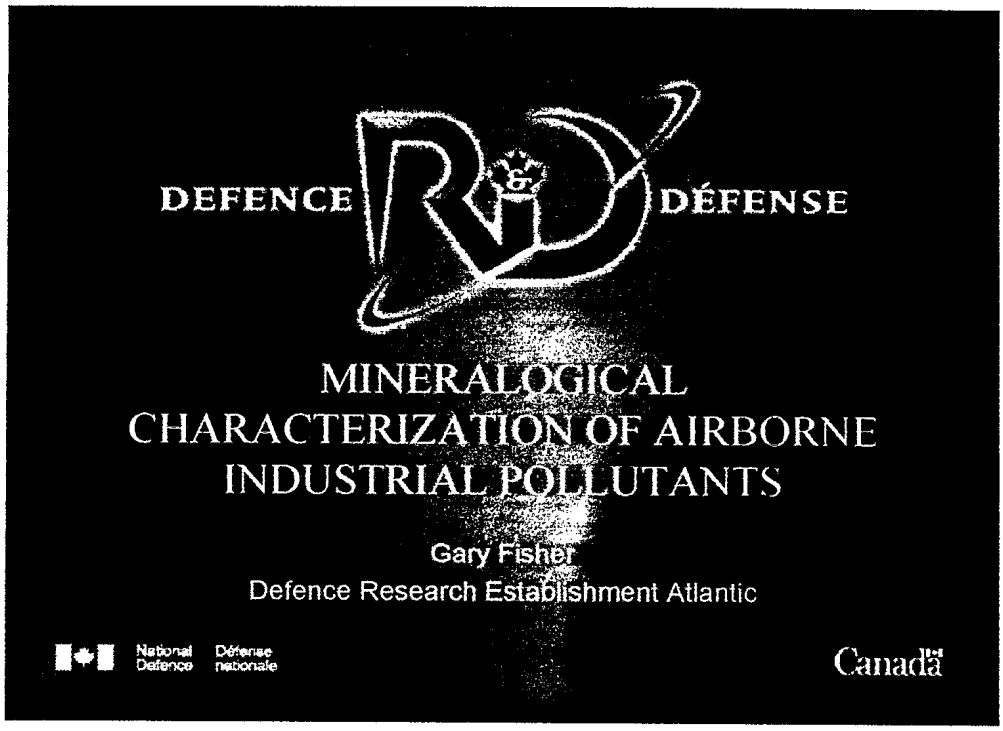
ABSTRACT

Increased awareness of environmental and health-related issues has lead to heightened concern about air quality in industrial and office settings. Often the airborne pollutants that cause personnel complaints of eye, nose and throat irritation are inorganic particulates released by industrial processes, dirty or inadequate ventilation systems, or poor housecleaning practices. Identification of these particulates and their source is a necessary first step to improving industrial air quality. However, due to the small quantities of airborne material available in even the dirtiest of samples, standard analytical techniques are not practical for such identification. This paper describes the use of transmission polarized light microscopy, both alone and in conjunction with scanning electron microscopy/energy dispersive x-ray microanalysis, as a means of identifying airborne inorganic particulates at the picogram level.



OUTLINE

- History
- Analysis options
  - X-ray diffraction
  - Scanning electron microscopy/x-ray microanalysis
  - Transmission polarized light microscopy
- Mineralogical characterization
- Results

HISTORY

- Industry/government respond to health & safety and political issues of the day
- 1970's - reduction in use of toxic industrial materials
  - asbestos, lead, PCBs
- 1980's - global environment
  - recycling, eco-products, spill prevention
- 1990's - personal working environment
  - ventilation issues, fugitive emissions, allergens, individual sensitivities

HISTORY

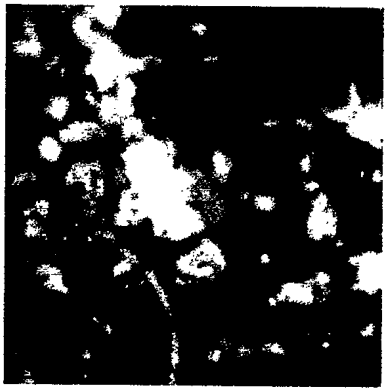
- Increase in general health complaints
  - eye/nose/throat irritations
  - headaches
  - nausea/drowsiness/general malaise
  - transitory

HISTORY

- Air quality issues
  - fumes, fugitive emissions, particulates
- Airborne particulate content is recognized as a health & safety issue
  - 50 $\mu g/m^3$ particles < 10 μm proposed limit

ANALYSIS OPTIONS

- Require a technique able to identify airborne particulates
  - Natural:
    - minerals, pollen, plant fibers
  - Synthetic:
    - fibers, soot (fly ash), minerals

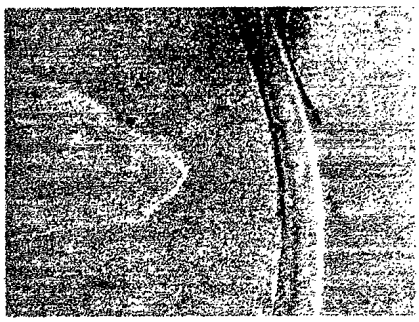


ANALYSIS OPTIONS

- X-ray diffraction
  - identify crystallographic species
  - problems with polymers and natural materials
  - insensitive: 5% detection limit
- Microscopic technique
  - Scanning electron microscopy/energy dispersive x-ray microanalysis (SEM/EDX)
  - Transmission polarized light microscopy

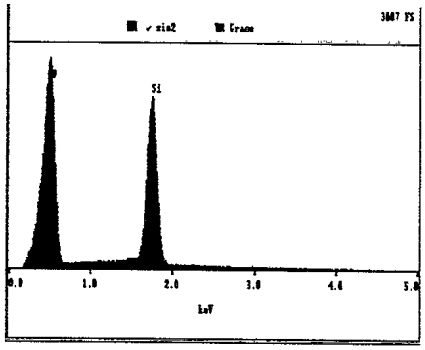
SEM/EDX

- Superior resolving power and depth of focus
- Non-conductive samples problematic
- No colour

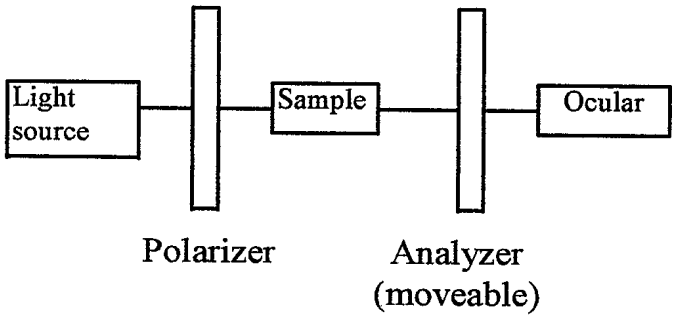


SEM/EDX

- X-ray emission enables chemical analysis
- Elemental analysis versus identification of species
  - quartz indistinguishable from glass



TRANSMISSION POLARIZED LIGHT MICROSCOPY



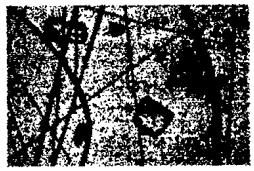
TRANSMISSION POLARIZED LIGHT MICROSCOPY

Sample Preparation

- Examined using stereomicroscope to select particle types and/or representative sample
- Sieved and/or crushed
- Sample mounted in refractive index fluid, $n_D = 1.550$
- Examined at low magnification (10X objective) to determine particle types

POLARIZED VS. UNPOLARIZED

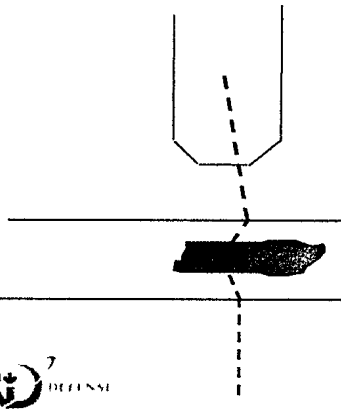
Unpolarized



Polarized

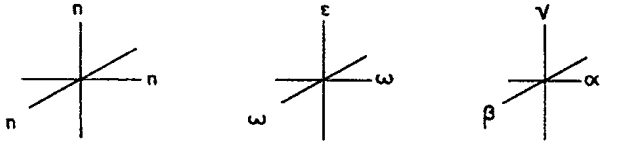
Crossed polars

TRANSMITTANCE PLM



OPTICAL PROPERTIES

- $n = C_v/C_m$
- Optical isotropy - 1 refractive index
- Optical anisotropy - multiple refractive indices



Isotropic
cubic

Anisotropic
tetragonal
hexagonal
orthorhombic
monoclinic
triclinic

POLARIZED VS. UNPOLARIZED

Unpolarized | Polarized | Crossed polars

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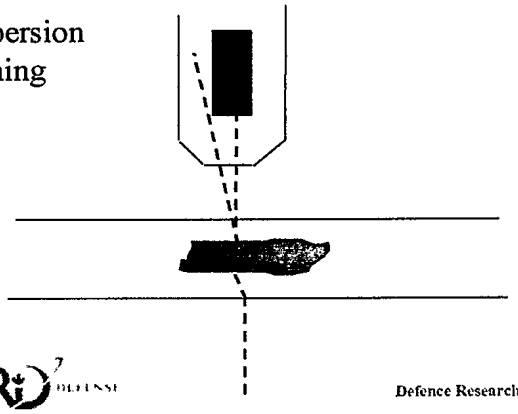
DETERMINATION OF REFRACTIVE INDEX

Dispersion staining



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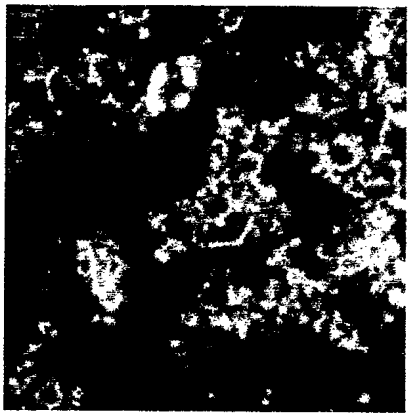
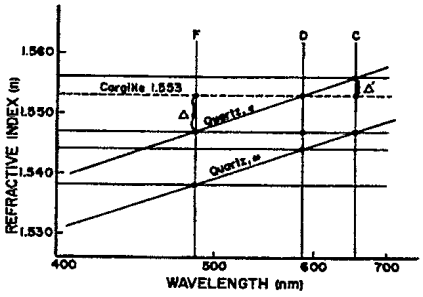
DETERMINATION OF REFRACTIVE INDEX

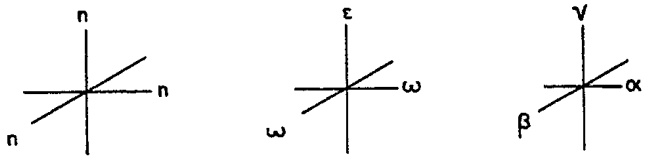


DETERMINATION OF REFRACTIVE INDEX



CHARACTERIZATION OF NON-CUBIC CRYSTALS

Anisotropic crystals show 1 or 2 refractive indices, regardless of orientation



Isotropic
cubic

Anisotropic
tetragonal
hexagonal
orthorhombic
monoclinic
triclinic

CHARACTERIZATION OF NON-CUBIC CRYSTALS

UNIAXIAL

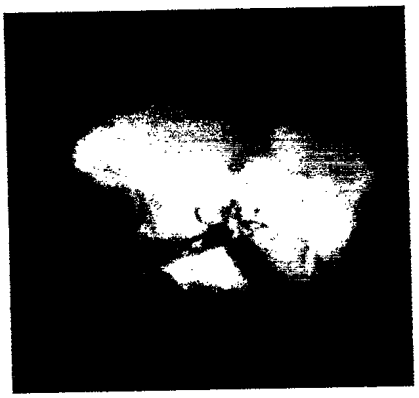
BIAXIAL

CHARACTERIZATION OF NON-CUBIC CRYSTALS

BIREFRINGENCE

- Light exiting one axis is "retarded" relative to the other
- Yields interference colors

$$B = \frac{\text{retardation (nm)}}{\text{thickness (nm)}}$$



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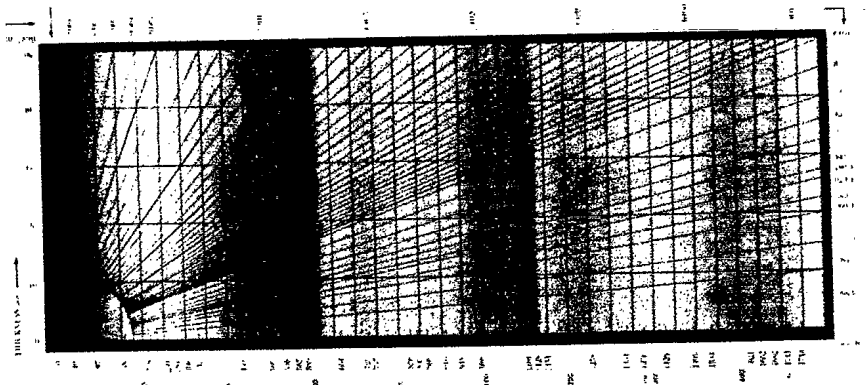
CHARACTERIZATION OF NON-CUBIC CRYSTALS



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SUMMARY

ISOTROPIC MINERALS

- Cubic or amorphous
- Measure n by dispersion staining
- Color
- X-ray microanalysis can aid identification

ANISOTROPIC MINERALS

- Conoscopic imaging to determine uniaxial/biaxial
- Measure birefringence from Michel-Levy chart
- Color/morphology
- X-ray microanalysis can aid identification

DEFENCE R&D DEFENSE

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MINERAL PROPERTIES

MINERAL	B	n	SYSTEM
Halite	NA	1.544	Cubic
Corundum	0.007	ϖ - 1.772 ε - 1.763	Rhomb.
Quartz	0.009	ω - 1.544 ε - 1.553	Rhomb.
Calcite	0.190	ω - 1.740 ε - 1.550	Rhomb.
Gypsum	0.010	α - 1.521 β - 1.526 γ - 1.531	Monoclinic

DEFENCE R&D DEFENSE

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RESULTS

Background Mineral Content

- quartz, sodium chloride, gypsum ($CaSO_4 \cdot 2H_2O$)

Problem Minerals

- quartz, iron oxides, rutile (TiO2), ground glass

Other Materials

- fibers, hair (human and rodent), pollen/seed hairs

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